

ing multi-level LOD terrain using triangular patches according to the embodiment of the present invention.

[0033] The hierarchical mesh is specifically configured to have a multi-level LOD with use of the triangular patches. The hierarchical mesh can be obtained by performing sequential operations of: configuring a two-dimensional square mesh with evenly spaced grids; and dividing each grid in the direction from a top right point of the grid to a bottom left point of the grid to obtain triangular patches constructing isosceles right triangles. The isosceles right triangles denoted with dots configure one patch with the highest LOD. At this point, there are $k \times k$ of isosceles right triangles, where k represents the number of vertical and horizontal grids of level m . The $k \times k$ number of the patches of level m are collected to configure triangular patches each at the LOD level of $m+1$. FIG. 2 particularly represents the two-level hierarchical mesh including levels m and $m+1$. In this case, k is 4. The hierarchical mesh is repeated n times depending on a need of a system, so that an n -level hierarchical mesh including level 1, level 2, . . . , and level n can be configured.

[0034] FIG. 3 is a diagram illustrating an n -level hierarchical mesh according to an embodiment of the present invention. In FIG. 3, the number of grids (i.e., k) of triangular patches with the highest LOD is 3, and an n -level hierarchical mesh including the levels 1 to n is illustrated. The number of the grids ' k ' and the number of levels ' n ' can be determined depending on a need of a system such as a determined LOD, memory resources and a system speed. The patch that has the highest LOD includes 9 (3×3) of unit triangular patches at the highest level (i.e., level 1). The unit triangular patches are dotted in FIG. 3. Using the 9 triangular patches of level 1, triangular patches of an upper hierarchy that is at level 2 are configured. Using 9 of triangular patches of level $n-1$, the hierarchical mesh of level n is configured. Therefore, assuming that k is the number of horizontal and vertical grids of an lower level (i.e., level m , higher resolution), level $m+1$ includes $k \times k$ of triangular patches (unit triangular patches) of the lower level are included in triangular patches of the upper hierarchy that is one level higher than the lower hierarchy (i.e. level m).

[0035] FIG. 5 is a diagram illustrating an exemplary case of arranging each vertex of a hierarchical mesh with respect to regularly sampled pieces of information on height of a target image. The patch configuration unit 11 regularly samples pieces of information on height of a target image inputted from the input device 20, and allocates the pieces of the information to each vertex of the hierarchical mesh obtained according to the embodiment of the present invention. As illustrated in FIG. 4, a specific piece of index information is allocated to each vertex of the individual unit triangles and triangular patches. Therefore, the index information includes the regularly sampled pieces of the information on height of the target image. The LOD determination unit 12 and the patch connection unit 13 are set to be precedently provided with the index information of the vertices of the triangular patches. Hence, even if the triangular patch configuration unit 11 transmits only the index information of each vertex of the hierarchical mesh to the LOD determination unit 12 and the patch connection unit 13, the LOD determination unit 12 and the patch connection unit 13 can determine the information on the height of the target image allocated to vertices of the triangular patches corre-

sponding to the individual pieces of the index information using the received pieces of the index information. The triangular patch configuration unit 11 separately transmits the index information for each vertex to minimize information on polygons transmitted to the LOD determination unit 12 and the patch connection unit 13, and thus, the index information for each vertex can be transmitted without being overlapped. Accordingly, when the indexed hierarchical mesh according to the embodiment of the present invention is used, an amount of data to be transmitted can be minimized and a transmission speed can be increased by approximately 3-fold at maximum in a graphic pipe line supporting indexed polygons.

[0036] The LOD determination unit 12 determines an appropriate LOD level according to a view point of a current virtual camera to represent the multi-level target image, which is constructed in precedent processes employing the patch configuration unit 11, on the display device 30 in real time. In the assumption that a virtual character exists within a three-dimensional virtual space constructed in a computer system, the view point of the current virtual camera is a view point of the virtual character seeing the virtual space. As a method for determining the LOD level for the target image according to the view point of the current virtual camera, a method of determining the LOD level according to an error of each triangular patch at a screen and a method of determining the LOD level according to a distance between the vertex of each triangular patch and the virtual camera.

[0037] Particularly, the illustrated diagram in FIG. 5 is an exemplary LOD distribution of each triangular patch when the LOD is determined based on the error at the screen (hereinafter referred to as "screen error"). On the basis of the view point of the current virtual camera expressed with a reference denotation C, it is illustrated in FIG. 5 that the LOD of each triangular patch is determined according to the screen error generated when the target image (e.g., terrain) is represented on the screen in large scale or small scale according to a certain ratio. The triangular patches corresponding to dotted regions are set to have a higher LOD level than those triangular patches corresponding to not-dotted regions.

[0038] FIG. 6 is a diagram illustrating an exemplary LOD distribution of an individual triangular patch when an LOD level is determined based on a distance with respect to a virtual camera. Particularly, FIG. 6 illustrates the case of determining the LOD level according to a distance of the target image apart from the current virtual camera expressed with a reference denotation C within a virtual space. If the target image is a terrain model, the terrain allocated in a short distance from the virtual camera C, for instance, a mountain is represented with a high LOD level, whereas a background in a long distance is represented with a low LOD level. In FIG. 6, the close areas correspond to a region marked with dots, and the remote areas correspond to a region without dots.

[0039] The patch connection unit 13 makes a connection between hierarchically constructed triangular patches with different LOD levels without a gap. The hierarchical mesh according to the present embodiment described in FIG. 3 to FIG. 6 represents a portion of the target image with a higher resolution as a triangular patch of an lower hierarchy (e.g., level n) constructed with a plurality of unit triangular